SECTION – 4

CONCRETE AND ALLIED WORKS

Table of Contents

CONCRETE AND ALLIED WORKS 1
4.1 Applicable Codes 1
4.1.1 Materials 1
4.1.2 Material Testing 1
4.1.3 Material Storage 1
4.1.4 Concrete Mix Design 1
4.1.5 Concrete Testing 1
4.1.6 Equipments 2
4.1.7 Codes of Practice 2
4.1.8 Construction Safety 2
4.1.9 Measurement 3
4.2 General 3
4.3 Materials 3
4.3.1 Cement 3
4.3.2 Aggregates (General) 3
4.3.3 Water 5
4.3.4 Reinforcement 5
4.3.5 Admixtures 5
4.3.6 Air Entraining Agents 6
4.4 Wastage 6
4.5 Samples and Tests 6
4.6 Storing of Materials 6
4.7 Concrete 7
4.7.1 General 7
4.7.2 Controlled Concrete 8
4.7.3 Design Mix Concrete 8
4.7.4 Nominal Mix Concrete 10
4.8 Formwork 11
4.8.1 Removal of Formwork 12
4.8.2 Technical Specifications for Sheet Piling 13
4.8.3 Applicable Code 14
4.9 Reinforcement Workmanship 17
4.10 Tolerances 18

4.10.1 Tolerances for R.C. Buildings 18
Variation from the Plumb 18
4.10.2 Tolerances in other structures 19
4.10.3 Tolerances in Formwork: 19
4.11 Preparation Prior to Concrete Placement 20
4.12 Transporting, Placing and Compacting Concrete 20
4.13 Mass Concrete Works 21
4.14 Curing 21
4.15 Construction Joints and Keys 22
4.15.1 Movement Joints 22
4.16 Foundation Bedding 22
4.17 Finishes 23
4.17.1 General 23
4.17.2 Surface Finish Type F1 23
4.17.3 Surface Finish Type F2 23
4.17.4 Surface Finish Type F3 23
4.17.5 Unformed Surfaces 23
4.17.6 Integral Cement Finish on Concrete Floor 24
4.18 Repair and Replacement of Unsatisfactory Concrete 24
4.19 Vacuum Dewatering of Slabs 24
4.20 Hot Weather Requirements 24
4.21 Liquid Retaining Structures 24
4.22 Testing Concrete Structures for Leakage 25
4.23 Optional Tests 25
4.24 Grouting 26
4.24.1 Standard Grout 26
4.24.2 Non-Shrink Grout 26
4.25 Inspection 26
4.26 Clean-Up 27
4.27 Acceptance Criteria 27
4.28 Mode of Measurement and Payment 27
4.29 Water stops 28
4.29.1 Material 28
4.29.2 Workmanship 29
4.29.3 Measurement 29
4.30 Curing, Protecting, Repairing and Finishing 29
4.30.1 Curing 29

4.30.2 Curing with Water 29
4.30.3 Continuous Spraying 29
4.30.4 Alternate Curing Methods 30
4.30.5 Curing Compound 30
4.30.6 Curing Equipment 30
4.31 `Protecting Fresh Concrete 30
4.32 Repair and Replacement of Unsatisfactory Concrete 30
4.32.1 General 30
4.32.2 Use of Epoxy 31
4.32.3 Method of Repair 31
4.32.4 Curing of Patched Work 31
4.33 Approval by the Engineer 31
4.33.1 Precast Concrete 31
4.33.1.1 General 31
4.33.1.2 Striking Forms 31
4.33.1.3 Precast Units 32
4.33.1.4 Curing 32
4.34 Slots, Openings, etc. 32
4.34.1 General 32
4.35 Preformed Fillers and Joint Sealing Compound 32
4.35.1 Materials 32
4.35.1.1 Sealant Type A 32
4.35.1.2 Sealant Type B 32
4.35.1.3 Sealant Type C 32
4.35.1.4 Sealant Type D 33
4.35.1.5 Sealant Type E 33
4.35.1.6 Approved Sealants 33
4.35.1.7 Workmanship 33
4.35.1.8 Measurement 34
4.36 Concreting Records 34

SECTION - 4

CONCRETE AND ALLIED WORKS

4.1 Applicable Codes

4.1.1 Materials

1) IS: 269 Specification for Ordinary Portland cement.
2) IS: 455 Specification for Portland slag cement.
3) IS: 1489 Specification for Portland-pozzolana cement (Part 1&2).
4) IS: 12330 Specification for sulphate resisting Portland cement.
5) IS: 383 Specification for coarse and fine aggregates from natural sources for concrete.
6) IS: 432 Specification for mild steel and medium (tensile steel bars and hard-drawn steel) wires for concrete reinforcement. (Part 1 and 2)
7) IS: 1786 Specification for high strength deformed steel bars and wires for concrete reinforcement.
8) IS: 1566 Specification for hard-drawn steel wire fabric for concrete reinforcement.
9) IS: 9103 Specification for admixtures for concrete.
10) IS: 2645 Specification for integral cement water- proofing compounds.
11) IS: 4990 Specification for plywood for concrete shuttering work.

4.1.2 Material Testing

1) IS: 650 Specification for standard sand for testing of cement
2) IS: 2430 Methods for sampling of aggregates for concrete.
3) IS.2386 Methods of test for aggregates for concrete (Parts 1 to 8)
4) IS: 3025 Methods of sampling and test (physical and chemical) for water used in industry.
5) IS.4031 Methods of physical tests for hydraulic cement (Parts 1 to 15)
6) IS: 4032 Method chemical analysis of hydraulic cement.
7) IS: 6925 Methods of test for determination of water soluble chlorides in concrete admixtures.

4.1.3 Material Storage

1) IS: 4082 Recommendations on stacking and storing of construction materials at site.

4.1.4 Concrete Mix Design

1) IS: 10262 Recommended guidelines for concrete mix design.
2) SP: 23 (S&T) Handbook on Concrete Mixes.

4.1.5 Concrete Testing

1) IS: 1199 Method of sampling and analysis of concrete.
2) IS: 516 Method of test for strength of concrete.
3) IS: 9013 Method of making, curing and determining compressive strength of accelerated cured concrete test specimens.
4) IS: 8142 Method of test for determining setting time of concrete by penetration resistance.

5) IS: 9284 Method of test for abrasion resistance of concrete.
6) IS: 2770 Methods of testing bond in reinforced concrete.

4.1.6 Equipments

1) IS: 1791 Specification for batch type concrete mixers.
2) IS: 2438 Specification for roller pan mixer.
3) IS: 4925 Specification for concrete batching and mixing plant.
4) IS: 5892 Specification for concrete transit mixer and agitator.
5) IS: 7242 Specification for concrete spreaders.
6) IS: 2505 General Requirements for concrete vibrators: Immersion type.
7) IS: 2506 General Requirements for screed board concrete vibrators.
8) IS: 2514 Specification for concrete vibrating tables.
9) IS: 3366 Specification for pan vibrators.
10) IS: 4656 Specification for form vibrators for concrete.
11) IS: 11993 Code of practice for use of screed board concrete vibrators.
12) IS: 7251 Specification for concrete finishers.
13) IS: 2722 Specification for portable swing weigh batchers for concrete (single and double bucket type).
14) IS: 2750 S Specification for steel scaffoldings.

4.1.7 Codes of Practice

1) IS: 456 Code of practice for plain and reinforced concrete.
2) IS: 457 Code of practice for general construction of plain and reinforced concrete for dams and other massive structures.
3) IS: 3370 Code of practice for concrete structures for storage of liquids (Parts 1 to 4)
4) IS: 3935 Code of practice for composite construction.
5) IS: 2204 Code of practice for construction of reinforced concrete shell roof.
6) IS: 2210 Criteria for the design of reinforced concrete shell structures and folded plates.
7) IS: 2502 Code of practice for bending and fixing of bars for concrete reinforcement.
8) IS: 5525 Recommendation for detailing of reinforcement in reinforced concrete works.
9) IS: 2911 Code of practice for Design and construction of Pile foundations. (Part 1 to 4)
10) IS: 9417 Specification for welding cold worked bars for reinforced concrete construction.
11) IS: 3558 Code of practice for use of immersion vibrators for consolidating concrete.
12) IS: 3414 Code of practice for design and installation of joints in buildings.
13) IS: 4326 Code of practice for earthquake resistant design and construction of building.
14) IS: 4014 Code of practice for steel tubular scaffolding (Parts 1 & 2)
15) IS: 2571 Code of practice for laying insitu cement concrete flooring.
16) IS: 7861 Code of practice for extreme weather concreting: Part 1 Recommended practice for hot weather concreting.
17) IRC: 112 Code of practice for Concrete Road Bridges.
18) IRC: 78 Standard Specifications and Code of Practice for Road Bridges.
18) IRC: 21 Standard Specifications and Code of Practice for Road Bridges.
19) IS: 919 Recommendation for limits and fits for engineering.
20) IS: 1597 Construction of Stone Masonry (Part I & II)

4.1.8 Construction Safety

1) IS: 3696 Safety code for scaffolds and ladders. (Parts 1 & 2)
2) IS: 7969 Safety code for handling and storage of building materials.

3) IS: 8989 Safety code for erection of concrete framed structures.

4.1.9 Measurement

1) IS: 1200 Method of measurement of building and Engineering works
2) IS: 3385 Code of practice for measurement of Civil Engineering works

4.2 General

The Engineer shall have the right at all times to inspect all operations including the sources of materials, procurement, layout and storage of materials, the concrete batching and mixing equipment and the quality control system. Such an inspection shall be arranged and the Engineer's approval obtained, prior to starting of concrete work. This shall, however, not relieve the Contractor of any of his responsibilities. All materials which do not conform to the Specifications shall be rejected.

Materials should be selected so that they can satisfy the design requirements of strength, serviceability, safety, durability and finish with due regards to the functional requirements and the environmental conditions to which the structure will be subjected. Materials complying with codes/standards shall generally be used. Other materials may be used after approval of the Engineer and after establishing their performance suitability based on previous data, experience or tests.

4.3 Materials

4.3.1 Cement

Unless otherwise called for by the Engineer, cement shall be ordinary Portland cement conforming to IS: 269. Where Portland pozzolana or slag cements are used, it shall be ensured that consistency of quality is maintained, there will be no adverse interactions between the materials and the finish specified is not marred.
Only one type of cement shall be used in any one mix. The source of supply, type or brand of cement within the same structure or portion thereof shall not be changed without approval from the Engineer. Damaged or reclaimed or partly set cement will not be permitted to be used and shall be removed from the site. The storage bins and storage arrangement shall be approved by the Engineer. Consignments of cement shall be stored as received and shall be consumed in the order of their delivery. Storage of cement shall be as per standard practices.

Cement which is not used within 90 days from its date of manufacture shall be tested at a laboratory approved by the Engineer and until the results of such tests are found satisfactory, it shall not be used in any work.

4.3.2 Aggregates (General)

Aggregates shall consist of naturally occurring stones (crushed or uncrushed), gravel and sand. They shall be chemically inert, strong, hard, clean, durable against weathering, of limited porosity, free from dust/silt/ organic impurities/deleterious materials and conform to IS: 383.

Aggregates such as slag, crushed over burnt bricks, bloated clay ash, sintered fly ash and tiles shall not be used.

Aggregates shall be washed and screened before use where necessary or if directed by the Engineer. Aggregate source shall be approved by BWSSB.

Aggregates containing reactive materials shall be used only after tests conclusively prove that there will be no adverse effect on strength, durability and finish, including long term effects, on the concrete.

The fineness modulus of sand shall neither be less than 2.2 nor more than 3.2.

The maximum size of coarse aggregate shall be as stated on the drawings but in no case greater than 1/4 of the minimum thickness of the member.

Plums 160 mm and above of a reasonable size may be used in mass concrete fill where directed. Plums shall not constitute more than 20% by volume of the concrete.
The natural/ river sand to be used shall be clean, sieved and of good quality. As far as possible natural/ river sand shall be used. Whenever there is scarcity of natural/ river sand, manufactured sand / crushed sand can be used to a maximum extent of 50% of total sand quantity for plastering items and 100% for concrete items. The certification by the concerned Executive Engineer, Quality Control is mandatory for usage of artificial/ manufactured sand.

All coarse and fine aggregates shall be stacked separately in stock piles in the material yard near the work site in bins properly constructed to avoid inter mixing of different aggregates. Contamination with foreign material and earth during storage and while heaping the materials shall be avoided. The aggregates must be of specified quality not only at the time of receiving at site but more so at the time of loading into mixer. Rakers shall be piled in layers not exceeding 1.20 m in height to prevent coning or segregation. Each layer shall cover the entire area of stockpile before succeeding layers are started. Aggregates that have become segregated shall be rejected.

Foreign Material Limitations in Fine Aggregate

S. No.	**Foreign Material**	**Percentage by weight**	
		Uncrushed	**Crushed**
1	Material finer than 75 micron BIS	3.0	15.0
2	Shale	1.0	-
3	Coal & Lignite	1.0	1.0
4	Clay lumps	-	1.0
Total		**5.0**	**17.0**

Grading of Sand for Fine Aggregate

BIS:Sieve Designation	**Grading Zone I**	**Grading Zone II**	**Grading Zone III**	**Grading Zone IV**
10 mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	95-100
2.36 mm	60-95	75-100	85-100	95-100
1.18 mm	30-70	55-90	75-90	90-100
600 µm	15-34	35-59	60-79	80-100

Grading of Sand for Course Aggregate

BIS: Sieve Size	**Percentage passing for single sized aggregate of normal size**					**Percentage passing for graded aggregate of normal size**			
	40 mm	**20 mm**	**16 mm**	**12.5 mm**	**10 mm**	**40 mm**	**20 mm**	**16 mm**	**12.5 mm**
63 mm	100	-	-	-	-	-	-	-	-
40 mm	85-100	100	-	-	-	95-100	100	-	-
20 mm	0-20	85-100	100	-	-	30-70	95-100	100	100
16 mm	-	-	85-100	100	-	-	-	90-100	-
12.5	-	-	-	85-100	100	-	-	-	90-100

BIS: Sieve Size	**Percentage passing for single sized aggregate of normal size**					**Percentage passing for graded aggregate of normal size**			
	40 mm	**20 mm**	**16 mm**	**12.5 mm**	**10 mm**	**40 mm**	**20 mm**	**16 mm**	**12.5 mm**
mm									
10 mm	0-5	0-20	0-30	0-45	85-100	10-35	25-55	30-70	40-85
4.75 mm	-	0-5	0-5	0-10	0-20	0-5	0-10	0-10	0-10
2.36 mm	-	-	-	-	0-5	-	-	-	-

Foreign Material Limitations in Coarse Aggregate

S. No.	**Foreign Material**	**Percentage by weight**	
		Uncrushed	**Crushed**
1	Material finer than 75 micron BIS Sieve	3.0	3.0
2	Coal and Lignite	1.0	1.0
3	Clay Lumps	1.0	1.0
4	Soft Fragments	3.0	-
Total		**8.0**	**5.0**

4.3.3 Water

Water used for both mixing and curing shall conform to IS: 456. Potable waters are generally satisfactory. Water containing any excess of acid, alkali, sugar or salt shall not be used. Contractor shall also use treated water being sold by BWSSB, to end exploitation of ground water.

4.3.4 Reinforcement

In general, reinforcement shall conform to HYSD-CRS-500 and other reinforcement bars shall conform to IS: 432 or IS: 1786 and welded wire fabric to IS: 1566 as shown or specified on the drawing.

All reinforcement shall be clean, free from pitting, oil, grease, paint, loose mill scales, rust, dirty, dust, or any other substance that will destroy or reduce bond.

4.3.5 Admixtures

Accelerating, retarding, water-reducing and air entraining admixtures shall conform to IS: 9103 and integral water proofing admixtures to IS: 2645.

Admixtures may be used in concrete as per manufacturer's instructions only with the approval of the Engineer. An admixture's suitability and effectiveness shall be verified by trial mixes with the other materials used in the works. If two or more admixtures are to be used simultaneously in the same concrete mix, their interaction shall be checked and trial mixes done to ensure their compatibility. There should also be no increase in risk of corrosion of the reinforcement or other embedment.

Calcium chloride shall not be used for accelerating set of the cement for any concrete containing reinforcement or embedded steel parts. When calcium chloride is permitted such as in mass concrete works, it shall be dissolved in water and added to the mixing water by an amount not exceeding 1.5 percent of the weight of the cement in each batch of concrete. The designed concrete mix shall be corrected accordingly.

4.3.6 Air Entraining Agents

Neutralized Vinson resin or other approved air in the concrete mix agents shall conform to the requirements of ASTM standard 6.260; Air Entraining Admixtures for Concrete. The recommended total air content of the concrete is 4% + 1%. The method of measuring air content shall be as per IS: 1199.

4.3.5.1 Water Reducing Admixtures

Water reducing lignosulfonate admixture may be added in quantities approved by the Engineer. The admixtures shall be added in the form of a solution.

4.3.5.2 Retarding Admixtures

Retarding agents may be added to the concrete mix in quantities approved by the Engineer.

4.3.5.3 Water Proofing Agent

Water proofing agents shall conform to IS: 2645.

4.3.5.4 Other Admixtures

The Engineer may at his discretion allow the contractor to use any other admixture in the concrete.

4.4 Wastage

Wastage allowance for cement and steel and higher rolling margin for steel shall be considered in the item rate and no extra payment shall become payable to the Contractor on any account.

4.5 Samples and Tests

All materials used for the works shall be tested before use. Manufacturer's test certificate shall be furnished for each batch of cement/steel and when directed by the Engineer samples shall also be got tested by the Contractor in a laboratory approved by the Engineer at no extra cost to Employer. Sampling and testing shall be as per IS: 2386 under the supervision of the Engineer. Water to be used shall be tested to comply with requirements of IS: 456.

The Contractor shall furnish manufacturer's test certificates and technical literature for the admixture proposed to be used. If directed, the admixture shall be got tested at an approved laboratory at no extra cost.

4.6 Storing of Materials

All materials shall be stored in a manner so as to prevent its deterioration and contamination which would preclude its use in the works. Requirements of IS: 4082 shall be complied with.

The Contractor will have to make his own arrangements for the storage of adequate quantity of cement. If such cement is not stored properly and has deteriorated, the material shall be rejected. Cement bags shall be stored in dry weatherproof shed with a raised floor, well away from the outer walls and insulated from the floor to avoid moisture from ground. Not more than 15 bags shall be stacked in any tier. Storage arrangement shall be approved by the Engineer. Storage under tarpaulins shall not be permitted. Each consignment of cement shall be stored separately and consumed in its order of receipt.

Each size of coarse and fine aggregates shall be stacked separately and shall be protected from leaves and contamination with foreign material. The stacks shall be on hard, clean, free draining bases, draining away from the concrete mixing area.

The Contractor shall make his own arrangements for storing water at site in tanks to prevent contamination.

The reinforcement shall be stacked on top of timber sleepers to avoid contact with ground/water. Each type and size shall be stacked separately.

4.7 Concrete

4.7.1 General

Concrete grade shall be as designated on drawings. In concrete grade M15, M20 etc. the number represents the specified characteristic compressive strength of 150 mm cube at 28 days, expressed in N/sq.mm as per IS:456. Concrete in the works shall be "DESIGN MIX CONCRETE" or "NOMINAL MIX CONCRETE". All concrete works of grade M10 and M15 shall be NOMINAL MIX CONCRETE whereas all other grades, M20 and above, shall be DESIGN MIX CONCRETE.
The grades of concrete to be used are noted on the drawings. In addition, the following table shall apply unless specified otherwise.

Structure	Grade of Concrete	Max. Aggregate Size
1. All Liquid retaining structures / Wet wells/ Bridges/ Piles/ Pile caps	M30	20 mm
2. Sewage Pumping Stations/ Buildings		
(a) for foundation raft	M25	20 mm
(b) for walls, columns, floor beams, circular floor slab	M25	20 mm
(c) for beams, slabs etc.	M25	20 mm
3. Valve chambers		
(a) for foundation raft	M25	20 mm
(b) walls, columns	M25	20 mm
(c) for slabs, beams, etc.	M25	20 mm
4. Anchor blocks/ Thrust blocks/ Antiflotation blocks	M20	40 mm
5. Saddles	M25	20 mm
6. Pipeline embankment, grade slab, ramps, footings under walls, SW drain coping etc	M15	20 mm
7. Bridges		
Foundation of piers and abutments	M30	20 mm
Piers and abutments with wing walls	M30	20 mm
Hammer head of pipes	M30	20 mm
8. Causeway	M20	20 mm
9. Manholes	M30	20 mm

4.7.2 Controlled Concrete

All concrete in the works shall be "Controlled Concrete" as defined in IS: 456 except for M-10 for which normal mix concrete shall be used. Whether reinforced or otherwise, all concrete works to be carried out under this specification shall be divided into the following classifications:

Note: It shall be very clearly understood that whenever the grade of concrete such as M-20, etc. is specified it shall be contractor's responsibility to ensure the minimum crushing strength stipulated for the respective grade of concrete is obtained at works.

Class	**Preliminary Test N/mm^2**		**Works Test N/mm^2**		**Maximum size of aggregate mm**	**Locations for use**
	At 7 Days	**At 28 Days**	**At 7 Days**	**At 28 Days**		
M30	25.0	38.0	20.0	30.0	40 or 20	As indicated in the specifications or as required
M25	22.0	32.0	17.0	25.0	40 or 20	-do-
M15	13.5	20.0	10.0	15.0	40 or 20	-do-

4.7.3 Design Mix Concrete

4.7.3.1 Mix Design & Testing

For Design Mix Concrete, the mix shall be designed according to IS: 10262 and SP: 23 to provide the grade of concrete having the required workability and characteristic strength not less than appropriate values given in IS: 456. The design mix shall in addition be such that it is cohesive and does not segregate and should result in a dense and durable concrete and also capable of giving the finish as specified. For liquid retaining structures, the mix shall also result in water tight concrete. The Contractor shall exercise great care while designing the concrete mix and executing the works to achieve the desired result based on SP23 Fig 37 of minimum cement paste volume in concrete for durability.

The minimum cement content for Design Mix Concrete shall be as per Table-5 of IS: 456 and for Pile foundations as per IS: 2911 or as given below, whichever is higher.

Grade of Concrete	Minimum Cement Content in Kg/Cu.m of Concrete
M20	320
M25	360
M30	400

The minimum cement content stipulated above shall be adopted irrespective of whether the Contractor achieves the desired strength with less quantity of cement. The Contractor's quoted rates for concrete shall provide for the above eventuality and nothing extra shall become payable to the Contractor in this account. Even in the case where the quantity of cement required is higher than that specified above to achieve desired strength based on an approved mix design, nothing extra shall become payable to the Contractor.

The Contractor shall submit details of the source of all material and the proposed quantities of each ingredient per cubic metre of fully compacted concrete. The Contractor shall then make trial mixes for each class of concrete using the same Contractor's Equipment and the same materials as are proposed for the Permanent Works. The Contractor shall give 24 hours notice of such trials to enable the Engineer's Representative to attend. For each trial mix, three separate batches of concrete shall be made by the Contractor and will be tested at 28 days all in accordance with IS: 516. Such trial mixes shall not be the first batch through the plant in any one sequence of concrete production.

The Contractor shall not commence concreting in the Permanent Works until details of trial mixes and test results for each class of concrete have been submitted to and approved by the Engineer.

Unless otherwise specified, only medium graded fine aggregate shall be used.

A trial mix design will be approved by the Engineer with respect to strength if the average compressive strength of the nine cubes so tested is more than the target means strength appropriate to the grade of concrete.

For concrete of Grade 30 and over the Contractor shall cast two sample wall panels 48 hours apart. Each shall be cast in two equal lifts to form a wall panel having one horizontal construction joint formed in the manner proposed by the Contractor for the Works. The top surface of the second lift shall have a Type U3 finish. The panels shall not be touched up after stripping. The panels shall be 300 mm thick and 1.5 m long by 1.5 m high. The Contractor shall not commence concreting in the Permanent Works until the test panels have been approved by Engineer.

The Contractor shall not alter the approved mix proportions or the approved source of supply of any of the ingredients without having previously obtained the approval of the Engineer.

During production, the Engineer may require trial mixes to be made before a substantial change is made in the materials or in the proportions of the materials to be used.

It shall be the Contractor's sole responsibility to carry out the mix designs at his own cost. He shall furnish to the Engineer at least 30 days before concreting operations, a statement of proportions proposed to be used for the various concrete mixes and the strength results obtained. The strength requirements of the concrete mixes ascertained on 150 mm cubes as per IS:516 shall comply with the requirements of IS:456 as follows:

Grade of Concrete	**Minimum Compressive Strength N/sq.mm at 7 days**	**Specified Characteristic Compressive Strength N/sq.mm at 28 days**
M 15	10.0	15.0
M 20	13.5	20.0
M 25	17.0	25.0
M 30	20.0	30.0
M 35	23.5	35.0

A range of slumps which shall generally be used for various types of construction unless otherwise instructed by the Engineer is given below:

4.7.3.2 Workability

The workability of concrete shall be checked at frequent intervals by slump test. Where facilities exist and if required by the Engineer, alternatively the compacting factor test in accordance with IS: 1199 shall be carried out. The degree of workability necessary to allow the concrete to be well consolidated and to be worked into the corners of form work and round the reinforcement to give the

required surface finish shall depend on the type and nature of the structure and shall be based on experience and tests

4.7.3.3 Workmanship

All workmanship shall be according to the latest relevant standards. Before starting a pour the contractor shall obtain the approval of the Engineer in a "Pour Card" maintained for this purpose. He shall obtain complete instructions about the material and proportion to be used, slump, workability of water per unit of cement, number of test cubes to be taken, finishing to be done and any admixture to be added etc

Structure/Member	Slump in millimeters	
	Maximum	Minimum
Reinforced foundation walls and footings	75	40
Plain footings, caissons and substructure walls	75	40
Slabs, Beams and reinforced walls	100	50
Pump & miscellaneous Equipment Foundation	75	40
Building columns	100	40
Pavements	50	40
Heavy mass construction	50	40

Note: All concreting done for water retaining structures shall have a minimum slump value of 80 mm and maximum of 100 mm

4.7.3.4 Batching & Mixing of Concrete

It is expected that batching plants of minimum 30 m^3 capacity, with two silos and pumps for placing concrete shall be used. Proportions of aggregates and cement, as decided by the concrete mix design, shall be by weight. These proportions shall be maintained during subsequent concrete batching by means of weigh batchers capable of controlling the weights within one percent of the desired value.

Amount of water added shall be such as to produce dense concrete of required consistency, specified strength and satisfactory workability and shall be so adjusted to account for moisture content in the aggregates. Water- cement ratio specified for use by the Engineer shall be maintained. Each time the work stops, the mixer shall be cleaned out, and while recommencing, the first batch shall have 10% additional cement to allow for sticking in the drum.

Arrangement should be made by the Contractor to have the cubes tested in an approved laboratory or in field with prior consent of the Engineer. Sampling and testing of strength and workability of concrete shall be as per IS: 1199, IS: 516 and IS: 456.

4.7.4 Nominal Mix Concrete

4.7.4.1. Mix Design & Testing

Mix design and preliminary tests are not necessary for Nominal Mix Concrete. However works tests shall be carried out as per IS: 456. Proportions for Nominal Mix Concrete and w/c ratio may be adopted as per Table 9 of IS: 456. However it will be the Contractor's sole responsibility to adopt appropriate nominal mix proportions to yield the specified strength.

4.7.4.2. Batching & Mixing of Concrete

Based on the adopted nominal mixes, aggregates shall be measured by volume. However cement shall be by weight only, using whole bags of cement.

4.8 Formwork

Formwork shall be all inclusive not be limited to shores, bracings, sides of footings, walls, beams and columns, bottom of slabs etc. including ties, anchors, hangers, inserts, falsework, wedges etc.

The design and engineering of the formwork as well as its construction shall be the responsibility of the Contractor. However, if so desired by the Engineer, the drawings and calculations for the design of the formwork shall be submitted to the Engineer for approval.

Formwork shall be designed to fulfill the following requirements:

1. Sufficiently rigid and tight to prevent loss of grout or mortar from the concrete at all stages and appropriate to the methods of placing and compacting.

2. Made of suitable materials.

3. Capable of providing concrete of the correct shape and surface finish within the specified tolerance limits.

4. Capable of withstanding without deflection the worst combination of selfweight, reinforcement and concrete weight, all loads and dynamic effects arising from construction and compacting activities, wind and weather forces.

5. Capable of easily striking without shock, disturbance or damage to the concrete.

6. Soffit forms capable of imparting a camber if required.

7. Soffit forms and supports capable of being left in position if required.

8. Capable of being cleaned and/or coated if necessary immediately prior to casting the concrete. design temporary openings where necessary for these purposes and to facilitate the preparation of construction joints.

The formwork may be of timber, plywood, steel, plastic or concrete depending upon the type of finish specified. Sliding forms and slip form may be used with the approval of the Engineer. Timber for formwork shall be well seasoned, free from sap, shakes, loose knots, worm holes, warps and other surface defects. Joints between formwork and formwork and between formwork and structures shall be sufficiently tight to prevent loss of slurry from concrete, using seals if necessary.

The faces of formwork coming in contact with concrete shall be cleaned and two coats of approved mould oil applied before fixing reinforcement. All rubbish, particularly chippings, shavings, sawdust, wire pieces dust etc. shall be removed from the interior of the forms before the concrete is placed. Where directed, cleaning of forms shall be done by blasting with a jet of compressed air at no extra cost.

Forms intended for reuse shall be treated with care. Forms that have deteriorated shall not be used. Before reuse, all forms shall be thoroughly scraped, cleaned, nails removed, holes suitably plugged, joints repaired and warped lumber replaced to the satisfaction of the Engineer. The Contractor shall equip himself with enough shuttering to allow for wastage so as to complete the job in time.

Permanent formwork shall be checked for its durability and compatibility with adjoining concrete before it is used in the structure. It shall be properly anchored to the concrete.

Wire ties passing through beams, columns and walls shall not be allowed. In their place bolts passing through sleeves shall be used. Formwork spacers left insitu shall not impair the desired appearance or durability of the structure by causing spalling, rust staining or allowing the passage of moisture.

For liquid retaining structures, sleeves shall not be provided for through bolts nor shall through bolts be removed if provided. The bolts, in the latter case, shall be cut at 25 mm depth from the surface and the hole made good by cement mortar of the same proportion as the concrete just after striking the formwork.

All corners and angles exposed in the finished structure shall have chamfers or fillets of 20 mm x 20 mm size, except where specified in the drawings.

Forms for substructure may be omitted when, in the opinion of the Engineer, the open excavation is firm enough (in hard non-porous soils) to act as a form. Such excavations shall be larger, as approved by the Engineer, than that required as per drawing to compensate for irregularities in excavation.

The Contractor shall provide adequate props carried down to a firm bearing without overloading any of the structures.

The shuttering for beams and slabs shall be so erected that the side shuttering of beams can be removed without disturbing the bottom shuttering. If the shuttering for a column is erected for the full height of the column, one side shall be built up in sections as placing of concrete proceeds or windows left for placing concrete from the side to limit the drop of concrete to 1.0m or as approved by the Engineer. The Contractor shall temporarily and securely fix items to be cast (embedment's/ inserts) in a manner that will not hinder the striking of forms or permit loss of grout.

Formwork showing excessive distortion, during any stage of construction, shall be repositioned and strengthened. Placed concrete affected by faulty formwork, shall be entirely removed and formwork corrected prior to placement of new concrete at Contractor's cost.

The striking time for formwork shall be determined based on the following requirements:

(a) Development of adequate concrete strength;
(b) Permissible deflection at time of striking form work;
(c) Curing procedure employed - its efficiency and effectiveness;
(d) Subsequent surface treatment to be done;
(e) Prevention of thermal cracking at re-entrant angles;
(f) Ambient temperatures; and
(g) Aggressiveness of the environment (unless immediate adequate steps are taken to prevent damage to the concrete).

Under normal circumstances (generally where temperatures are above 20^{o}C) forms may be struck after expiry of the time period given in IS: 456 unless approved otherwise by the Engineer. For Portland Pozzolana/slag cement the stripping time shall be suitably modified as approved by the Engineer. It is the Contractor's responsibility to ensure that forms are not struck until the concrete has developed sufficient strength to support itself, does not undergo excessive deformation and resist surface damage and any stresses arising during the construction period.

4.8.1 Removal of Formwork

Formwork shall be so designed as to permit any removal without resorting to hammering or levering against the surface of the concrete. The periods of time elapsing between the placing of the concrete and the striking of the loads likely to be imposed on the concrete and shall in any case be not less than the periods, shown in Table below. Where soffit formwork is constructed in a manner during and after such removal of a sufficient number of adequate supporting props in an undisturbed condition, the Contractor may, with the agreement of the Engineer, remove the formwork at the earlier times listed below provided that the props are left in position.

Table 12

Position of Formwork	Days for Striking
Walls	1
Sides of beams and columns	1
Slabs (Drops left under)	3
Props to slabs (span not exceeding 4.5m)	7
Props to slabs (span exceeding 4.5 m)	14
Beams soffits (props left under)	21

Not withstanding the foregoing, the Contractor shall be held responsible for any damage arising from removal of formwork before the structure is capable of carrying its own weight and any incidental loading.

Striking shall be done slowly with utmost care to avoid damage to projections and without shock or vibration, by gently easing the wedges. If after removing the form work it is found that timber has been embedded in the concrete. It shall be removed and made good as specified earlier.

Reinforced temporary openings shall be provided, as directed by the Engineer, to facilitate removal of formwork which otherwise may be inaccessible.

The rods, clamps, form bolts, etc. which must be entirely removed from walls or similar structures shall be loosened not sooner than 24 hours not later than 40 hours after the concrete has been deposited. Ties, except those required to hold forms in place, may be removed at the same time. Ties, withdrawn from walls and grade beams shall be pulled toward the inside face. Cutting ties back from the faces of the walls and grade beams will not be permitted.

4.8.2 Technical Specifications for Sheet Piling

4.8.2.1 General

Sheet piling is a form of driven piling using interlocking sheets of steel to obtain a continuous barrier in the ground. The main application of sheet pile is in retaining walls erected for the purpose of excavation to enable permanent works to proceed. Normally vibrating hammer/ impact hammer, crane and crawler drilling are to be used to establish sheet piles. The work shall be done as per BOQ provisions. The work shall include supply, installation and subsequent removal of all miscellaneous steel shapes, plates and connecting hardware when required to attach the sheeting to an existing substructure unit and/or facilitate stage construction.

All initial banking has to be formed at contractor's own cost for taking the machinery to drive the sheet piles. The area shall be filled driving of steel sheet piles with pit sand for leveling the ground.

Piles shall be driven, true to plumb and alignment. Hammer for sheet pile driving shall be drop hammer, steam hammer, air hammer, diesel hammer or vibratory hammer. Sheet pile driving shall commence initially with minimum impact of hammer, which can be increased later after ensuring that the piles are being driven vertically through the interlocking grooves along with designed alignment. The sheet piles are to be driven with batten welded at suitable intervals. The Steel Sheet Pile may be lifted at single point

4.8.3 Applicable Code

All work shall be carried out strictly in accordance with the Technical Specifications, unless otherwise approved by Engineer in writing. The Indian Standard Codes applicable to this section shall include but not limited to the following.

4.8.3.1 INDIAN STANDARDS (IS CODES)

IS 2314:1986 Specification for steel sheet piling sections (first revision)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 6/A 6M (2000) General Requirements for Rolled Structural Steel Bars,

Plates, Shapes, and Sheet Piling

ASTM A 328/A 328M (200) Steel Sheet Piling

ASTM A 572/A 572M (200) High-Strength Low-Alloy Columbium-Vanadium

Structural Steel

ASTM A 690/A 690M (1994) High-Strength Low-Alloy Steel H-Piles and

Sheet Piling for Use in Marine Environments

ASTM A 857/A 857M (1997el) Steel Sheet Piling, Cold Formed, Light Gage.

4.8.3.2 Transportation

The Contractor shall set up, in accordance with the construction schedule make all the necessary arrangements for hauling of all materials for the steel sheet pile driving so that all the materials will be available for immediate use whenever required:

a) All the steel sheet piles shall be delivered intact at the site without causing any permanent distortion in the member or injury or deformation at joints.

b) Care shall be taken in handling such materials as tie-rods to avoid damage to the thread and shop coat painting.

c) Handling of such long members as walling shall be carried out in the same way as for the steel sheet piles.

4.8.3.3 Storage

a) Storage space for steel sheet piles shall be reasonably leveled and compacted. The site so selected should be got approved by the ENGINEER.

b) Steel sheet piles shall be stacked in such a way as to avoid strain or distortion in the materials.

c) Steel sheet piles shall be stacked up in such tiers as each consisting of not more than 3 piles, and between each tier wooden sleepers shall be inserted at intervals not exceeding 4m. Total height of stack shall not exceed 2m.

d) Tie-rods and accessories shall be sorted, stacked in accordance with their diameters and shall be stored under cover and not be directly exposed to weather.

e) The Contractor shall be responsible for safe handling, mobilization & demobilization and storage of piles and other materials. The rate for sheet pile driving shall include the cost for handling and storage of piles and other accessories, forming driving pit, formation and removal of earthen bund if required, all other requisites for successful driving of sheet pile.

4.8.3.4 Cutting of Sheet Pile

a) Cutting of steel sheet piles shall be done by means of a gas cutting device.

b) Steel sheet piles to be cut shall be free from curve and warp, and securely clamped on a level work table for cutting.

c) Use of a special jig is desirable to minimize deformation due to cutting

d) Whatever method is used in cutting, a certain degree of deformation is bound to occur. If the deformation is less than 40mm, it can be set right by hammering or by heat treatment to the deformed segment. If the deformation exceeds the above range, mechanical correction by means of jacks and press shall be made.

4.8.3.5 Sheet Pile Welding

a) Arc welding shall be adopted for steel sheet pile work.

b) Only skilled welders approved by the ENGINEER shall be engaged for the work.

c) Welding equipment shall be AC rectifiers / arc-welding unit. Welding rods shall be those conforming to the relevant IS or equivalent and subject to prior approval of ENGINEER.

d) If any welding is rejected by the ENGINEER, the Contractor shall perform the welding again by cutting off at the weld at his cost. All the costs thereof shall be borne by the Contractor.

4.8.3.6 Materials

Metal sheet piling material shall be conforming to IS:2314 or equivalent ASTM standards. The interlocks of sheet piling shall be free-sliding, provide a swing angle suitable for the intended installation but not less than 5 degrees when interlocked, and maintain continuous interlocking when installed. Sheet piling [including special abricated sections] shall be [full-length] sections of the dimensions as shown in the drawing. Sheet piling shall be provided with standard pulling holes.

Metal plates, shapes, bolts, nuts, rivets, and other appurtenant fabrication and installation materials shall conform to manufacturer's standards and to the requirements specified in the respective sheet piling.

4.8.3.7 Extraction of Rejected Sheet Pile:

If the pile driving work has not been done to the specification, the Contractor shall extract the rejected pile. The extraction shall be such as to avoid damages to the adjoining piles, other structures and installations. Cost of extraction and replacement shall be borne by the Contractor.

4.8.3.8 Construction

The Contractor shall verify locations of all underground utilities before driving any sheet piling. Any disturbance or damage to existing structures, utilities or other property, caused by the Contractor's operation, shall be repaired by the Contractor in a manner satisfactory to the Engineer at no additional cost to the Department. The Contractor shall be responsible for determining the appropriate equipment necessary to drive the sheeting to the tip elevation(s) specified on the plans or according to the Contractor's approved design. The Contractor shall be responsible for determining the appropriate equipment necessary to drive the sheeting to the tip elevation(s) specified on the plans or according to the Contractor's approved design. The sheet piling shall be driven, as a minimum, to the tip elevation(s) specified, prior to commencing any related excavation. If unable to reach the minimum tip elevation, the adequacy of the sheet piling design will require re-evaluation by the PMC/ Owner prior to allowing excavation adjacent to the sheet piling in question. The Contractor shall not excavate

below the maximum excavation line shown on the plans without the prior permission of the Engineer. The sheet piling shall remain in place until the Engineer determines it is no longer required.

The sheet piling shall be removed and take away from site by the Contractor when directed by the Engineer. When allowed, the Contractor may elect to cut off a portion of the sheet piling leaving the rest in place. The remaining piling shall be a minimum of 12 in. (300 mm) below the finished grade or as directed by the Engineer. Removed sheet piling becomes the property of the Contractor. When an obstruction is encountered, the Contractor shall notify the Engineer and upon concurrence of the Engineer, the Contractor shall begin working to break up, push aside, or remove the obstruction. An obstruction shall be defined as any object (such as but not limited to, boulders, logs, old foundations etc.) where its presence was not obvious or specifically noted on the plans prior to bidding, that cannot be driven through or around with normal driving procedures, but requires additional excavation or other procedures to remove or miss the obstruction.

The following are the installation procedure:-

1 The alignment of sheet pile wall shall be correctly set up for the approval of the ENGINEER before commencing the sheet pile driving.

2 Guide frames and stakes shall be installed correctly and secured properly to ensure driving of piles on the centre line.

3 Steel sheet pile driving shall be performed by one of the following methods.

a) In driving single pile one by one, special care shall be exercised to keep each pile penetrating in strictly vertical direction.

b) In driving a group of piles (about 20 pieces simultaneously) a guide frame shall be used to keep them in a straight alignment, and in the initial stage all the piles shall be driven to a depth just enough to enable them to stand in positions. Then one or two pieces on both ends shall be driven down first, followed by the intermediate piles which shall be driven alternately in several stages to final level.

4 Prior to starting pile driving, the Contractor shall submit the driving method and time schedule for approval of the ENGINEER and in accordance with the sequence approved by the ENGINEER. The piles shall be driven vertically in the specified positions.

5 Pile driving:

a) Sheet pile driving shall commence initially with minimum impact of hammer and increased later after ensuring that the piles are being driven vertically in designed alignment.

b) Pile shall be driven with cap and cushion on top of the pile for protection against the impact of drop hammer.

c) Lengthening of pile, if required, shall be done by welding additional piece on to the top of pile already driven. The joints shall be as strong as the normal section of the pile.

d) In case interlocks of piles with adjacent ones are found loosened or dislocated during or after driving, such piles shall be pulled out and replaced with new ones or redone otherwise in accordance with instructions of the ENGINEER.

e) The Contractor shall take every step to ensure safety and to prevent accident while handling and driving piles. If any deviation from specified lines, fractured top, deficient or excessive penetration is observed during pile driving, the driving shall be suspended to take corrective measures as directed by the ENGINEER.

f) Necessary data and logs such as of the number of blows, length of penetration etc. during sheet pile driving shall be made and submitted in duplicate to the ENGINEER at no extra

cost. Format of driving log shall be got approved by ENGINEER prior to commencement of driving sheet piles.

6 Reformed steel sheet piles:

a) Reformed steel sheet piles shall be of three types, namely corner sheet pile, junction sheet pile and wedge sheet pile.

b) Corner sheet piles are used where centre line for driving turns to form an angle, and joined by welding to the sheet pile wall that has changed its direction.

c) Junction sheet piles are those to be used where two walls of sheet piles meet at right angle forming a T junction, and where the sizes of sheet pile change along the same line.

d) Wedge sheet piles are used to make up for the deviation of piles from the plumb line caused during driving. This type of pile is characterized by its wedge like shape, tapering downward to the tip.

e) Reformed steel sheet piles as mentioned above shall as a rule is manufactured in a factory. If it becomes inevitable to fabricate them in the field at site, the Contractor shall provide equipment and manufacturing means equivalent to those of the regular factory production and have close supervision and control over driving.

f) If the Contractor finds it necessary to use the reformed steel sheet piles, he shall obtain approval of the ENGINEER for the use, and fabricate the same at his own cost in accordance with the instructions of the ENGINEER.

4.8.3.9 Payment for Steel Sheet Piling

It may be noted that the measurement shall be taken for one side of the trench only and the Contractor shall be paid for one side only even though sheet pilling work is provided for both sides trench in accordance with the Contract drawings or as directed by the Engineer. The unit rate for steel sheet pile driving shall include the costs of material, transportation, driving and incidental costs towards replacement of the damaged steel sheet piles. The cost will also include the cost of waling and accessories.

4.9 Reinforcement Workmanship

Reinforcing bars supplied bent or in coils shall be straightened cold without damage. No bending shall be done when ambient temperature is below 5^{o}C. Local warming may be permitted if steel is kept below 100^{o} C.

All bars shall be accurately bent gradually and according to the sizes and shapes shown on the drawings/ schedules or as directed by the Engineer.
Re-bending or straightening incorrectly bent bars shall not be done without the approval of the Engineer.

Reinforcement shall be accurately fixed and maintained firmly in the correct position by the use of blocks, spacers, chairs, binding wire etc. to prevent displacement during placing and compaction of concrete. The tied in place reinforcement shall be approved by the Engineer prior to concrete placement. Spacers shall be of such materials and designs as will be durable, not lead to corrosion of the reinforcement and not cause spalling of the concrete cover.

Binding wire shall be 16 gauge soft annealed wires. Ends of the binding wire shall be bent away from the concrete surface and in no case encroach into the concrete cover.
Substitution of reinforcement, laps/splices not shown on drawing shall be subject to Engineer's approval.

4.10 Tolerances

Tolerance is a specified permissible variation from lines, grade or dimensions given in drawings. No tolerance specified for horizontal or vertical building lines or footings shall be construed to permit encroachment beyond the legal boundaries. Tolerance for formed and concrete dimensions shall be as per IS:456 unless specified otherwise.

4.10.1 Tolerances for R.C. Buildings

Variation from the Plumb

(i) In the lines and surfaces of columns, piers, walls and in arrises 5 mm per 2.5 m or 25 mm, whichever is less.

(ii) For exposed corner columns and other conspicuous lines

In any bay or 5 m maximum	-	5 mm
In 10 m or more	-	10 mm

Variation from the level or from the grades indicated on the drawings

(i) In slab soffits, ceilings, beam soffits, and in arises

In 2.5 m	-	5 mm
In any bay or 5 m maximum	-	10 mm
In 10 m or more	-	15 mm

(ii) For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines :

In any bay or 5 m maximum	-	5 mm
In 10 m or more	-	10 mm

Variation of the linear building lines from established position in plan and related position of columns, wall and partitions :

In any bay or 5 m maximum	-	10 mm
In 10 m or more	-	20 mm

Variation in the sizes and locations of sleeves, openings in walls and floors – 5 mm except in the case anchor bolts.

Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls

Minus	-	5 mm
Plus	-	10 mm

Footings

(i) Variation in dimension in plan

Minus	-	5 mm
Plus	-	50 mm

(ii) Misplacement or eccentricity

2% of footing width in the direction of misplacement but not more than 50 mm

(iii) Reduction in thickness

Minus - 5% of specified thickness subject to a maximum of 50 mm

Variation in steps

(i) In a flight of stairs

Rise	-	3 mm
Tread	-	5 mm

(ii) In consecutive steps

Rise	-	1.5 mm
Tread	-	3.0 mm

4.10.2 Tolerances in other structures

All structures

(i) Variation of the construction linear outline from established position in plan

In 5 m - 10 mm
In 10 m or more - 15 mm

(ii) Variations of dimensions to individual structure features from established positions

In 20 m or more - 25 mm
In buried construction - 50 mm

(iii) Variation from plumb, from specified batter or from curved surfaces of all structures

In 2.5 m - 10 mm
In 5 m - 15 mm
In 10 m or more - 25 mm
In buried construction - Twice the above amounts

(iv) Variation from level or grade indicated on drawings in slab, beams, soffits, horizontal grooves and visible arises.

In 2.5 m - 5 mm
In 7.5 m or more - 10 mm
In buried construction - Twice the above amounts

(iv) Variation in cross-sectional dimensions of columns, beams, buttresses, piers and similar members

Minus - 5 mm
Plus - 10 mm

(vi) Variation in the thickness of slabs, walls, arch sections and similar members

Minus - 5 mm
Plus - 10 mm

Footing for columns, piers, walls, buttresses and similar members

(i) Variation of dimension in plan

Minus - 10 mm
Plus - 50 mm

(ii) Misplacement or eccentricity

2% footing width in the direction of misplacement but not more than 50 mm

(iii) Reduction in thickness

5% of specified thickness subject to a maximum of 50 mm.

Tolerance in fixing anchor bolts shall be as follows:

(i) Anchor bolts without sleeves : 1.5 mm in plan
(ii) Anchor bolts with sleeves : 5.0 mm in elevation
- for bolts upto and including 28 mm dia : 5 mm in all directions
- for bolts 32 mm dia and above : 3 mm in all directions
(iii) Embedded parts : 5 mm in all directions

4.10.3 Tolerances in Formwork:

The formwork shall be designed and constructed to the shapes, lines and dimensions shown on the drawings within the tolerances given below:

(i)	Deviation from specified dimensions of cross section of columns and beams	- 6 mm + 12 mm
(ii)	Deviations from dimensions of footings (Tolerances apply to concrete dimensions only, not to positioning of vertical reinforcing steel or dowels)	
	- Dimension in plan	- 12 mm + 50 mm

	- Eccentricity	0.02 times the width of the footing in the direction of deviation but not more than 50 mm
	- Thickness	± 0.05 times the specified thickness

4.11 Preparation Prior to Concrete Placement

Before concrete is actually placed in position, the inside of the formwork shall be cleaned and mould oil applied, inserts and reinforcement shall be correctly positioned and securely held, necessary openings, pockets, etc. provided.

All arrangements-formwork, equipment and proposed procedure, shall be approved by the Engineer. Contractor shall maintain separate Pour Card for each pour as per the format enclosed.

4.12 Transporting, Placing and Compacting Concrete

Concrete shall be transported from the mixing plant to the formwork with minimum time lapse by methods that shall maintain the required workability and will prevent segregation, loss of any ingredients or ingress of foreign matter or water.

In all cases concrete shall be deposited as nearly as practicable directly in its final position. To avoid segregation, concrete shall not be rehandled or caused to flow. For locations where direct placement is not possible and in narrow forms the Contractor shall provide suitable drops and "Elephant Trunks". Concrete shall not be dropped from a height of more than 1.0m.
Concrete shall not be placed in flowing water. Under water, concrete shall be placed in position by tremies or by pipeline from the mixer and shall never be allowed to fall freely through the water.

While placing concrete the Contractor shall proceed as specified below and also ensure the following:

1. Continuously between construction joints and pre- determined abutments.
2. Without disturbance to forms or reinforcement.
3. Without disturbance to pipes, ducts, fixings and the like to be cast in; ensure that such items are securely fixed. Ensure that concrete cannot enter open ends of pipes and conduits etc.
4. Without dropping in a manner that could cause segregation or shock.
5. In deep pours only when the concrete and formwork designed for this purpose and by using suitable chutes or pipes.
6. Do not place if the workability is such that full compaction cannot be achieved.
7. Without disturbing the unsupported sides of excavations; prevent contamination of concrete with earth. Provide sheeting if necessary. In supported excavations, withdraw the linings progressively as concrete is placed.
8. If placed directly onto hardcore or any other porous material, dampen the surface to reduce loss of water from the concrete.
9. Ensure that there is no damage or displacement to sheet membranes.
10. Record the time and location of placing structural concrete.
11. Cover blocks of required size depending on the cover of the reinforcement as mentioned in the drawings should be prepared in 1:3 cement mortar with fine aggregates.
12. The top surface of each pour and bedding planes shall be approximately horizontal unless otherwise instructed. Top layer should be rough and with key for further extension of work.
13. Concrete shall be compacted during placing with approved vibrating equipment until the concrete has been consolidated to the maximum practicable density, as specified in the IS, is free of pockets of coarse aggregate and fits tightly against all form surfaces, reinforcement and embedded fixtures.

14. Vibrators shall conform to BIS specifications. Type of vibrator to be used shall depend on the structures where concrete is to be placed.
15. Bleeding or free water on top of concrete being deposited into the forms, shall be the cause to stop the concrete pour and the conditions causing this defect corrected before any further Concreting is resumed.

Concrete shall normally be compacted in its final position within thirty minutes of leaving the mixer. Concrete shall be compacted during placing with approved vibrating equipment without causing segregation until it forms a solid mass free from voids thoroughly worked around reinforcement and embedded fixtures and into all corners of the formwork.

Immersion vibrators shall be inserted vertically at points not more than 450 mm apart and withdrawn slowly till air bubbles cease to come to the surface, leaving no voids. When placing concrete in layers advancing horizontally, care shall be taken to ensure adequate vibration, blending and melding of the concrete between successive layers.

Vibrators shall not be allowed to come in contact with reinforcement, formwork and finished surfaces after start of initial set. Concrete may be conveyed and placed by mechanically operated equipment after getting the complete procedure approved by the Engineer. The slump shall be held to the minimum necessary for conveying concrete by this method. When concrete is to be pumped, the concrete mix shall be specially designed to suit pumping. Care shall be taken to avoid stoppages in work once pumping has started.

Except when placing with slip forms, each placement of concrete in multiple lift work, shall be allowed to set for at least 24 hours after the final set of concrete before the start of subsequent placement. Placing shall stop when concrete reaches the top of the opening in walls or bottom surface of slab, in slab and beam construction, and it shall be resumed before concrete takes initial set but not until it has had time to settle as approved by the Engineer. Concrete shall be protected against damage until final acceptance.

4.13 Mass Concrete Works

Sequence of pouring for mass concrete works shall be as approved by the Engineer. The Contractor shall exercise great care to prevent shrinkage cracks and shall monitor the temperature of the placed concrete if directed.

4.14 Curing

Curing and protection shall start immediately after the compaction of the concrete to protect it from:

1. Premature drying out, particularly by solar radiation and wind
2. Leaching out by rain and flowing water
3. Rapid cooling during the first few days after placing
4. High internal thermal gradients
5. Low temperature or frost
6. Vibration and impact which may disrupt the concrete and interfere with its bond to the reinforcement.

All concrete, unless approved otherwise by the Engineer, shall be cured by use of continuous sprays or ponded water or continuously saturated coverings of sacking, canvas, hessain or other absorbent material for the period of complete hydration with a minimum of 7 days. The quality of curing water shall be the same as that used for mixing.
Where a curing membrane is approved to be used by the Engineer, the same shall be of a non-wax base and shall not impair the concrete finish in any manner. The curing compound to be used shall be approved by the Engineer before use and shall be applied with spraying equipment capable of a smooth, even textured coat.

Curing may also be done by covering the surface with an impermeable material such as polyethylene, which shall be well sealed and fastened.

4.15 Construction Joints and Keys

Construction joints will be as shown on the drawing or as approved by the Engineer. Concrete shall be placed without interruption until completion of work between construction joints. If stopping of concreting becomes unavoidable anywhere, a properly formed construction joint shall be made with the approval of the Engineer.

Dowels for concrete work, not likely to be taken up in the near future, shall be coated with cement slurry and encased in lean concrete as indicated on the drawings or as approved by the Engineer.

As soon as the exposed concrete has sufficiently hardened, the surface of the joint shall be water jetted or brushed with a stiff brush to expose the larger aggregate without being disturbed. Roughening of the surface by chipping or hacking will not generally be approved. Before placing fresh concrete against a construction joint all loose material shall be removed and the surface sluiced with water until it is perfectly clean, thereafter all ponded water should be removed.

When concreting is to be resumed on a surface which has not fully hardened, all laitance shall be removed by wire brushing, the surface wetted, free water removed and a coat of cement slurry applied. On this, a layer of concrete not exceeding 150 mm thickness shall be placed and well rammed against the old work. Thereafter work shall proceed in the normal way.

4.15.1 Movement Joints

1. Movement joints are defined as all joints intended to accommodate relative movement between adjoining parts of a structure, special provision being made where necessary for maintaining the water tightness of the joint. The contractor shall comply with the instructions of manufacturers of proprietary jointing materials and shall, if required by the Engineer, demonstrate that the jointing materials can be applied satisfactorily.
2. The surface of set concrete in a movement joint shall, as shown on the drawings, be painted with two coats of bituminous paint and new concrete shall be placed against it only when the paint is dry. Expansion joints shall be formed by a separating strip of approved preformed joint filler.
3. 3. Caulking grooves shall be provided. At all joints where a caulking groove is formed, immediately prior to caulking, the groove shall be wire brushed and loose material removed and blown out by compressed air. After the groove has dried, it shall be primed and caulked with approved sealing compound applied in accordance with the manufacturer's instructions. At all caulked joints, the face of the caulking strip and a width of concrete on either side shall be painted with two coats of paint having the same base as the sealing compound.

4.16 Foundation Bedding

All earth surfaces upon which or against which concrete is to be placed, shall be well compacted and free from standing water, mud or debris. Soft or spongy areas shall be cleaned out and back filled with either soil-cement mixture, lean concrete or clean sand compacted as approved by the Engineer. The surfaces of absorptive soils shall be moistened.

Concrete shall not be deposited on large sloping rock surfaces. The rock shall be cut to form rough steps or benches by picking, barring or wedging. The rock surface shall be kept wet for 2 to 4 hours before concreting.

4.17 Finishes

4.17.1 General

The formwork for concrete works shall be such as to give the finish as specified. The Contractor shall make good any unavoidable defects as approved consistent with the type of concrete and finish specified; defects due to bad workmanship (e.g. damaged or misaligned forms, defective or poorly compacted concrete) will not be accepted. The Contractor shall construct the formwork using the correct materials and to meet the requirements of the design and to produce finished concrete to required dimensions, plumbs, planes and finishes.

4.17.2 Surface Finish Type F1

The main requirement is that of dense, well compacted concrete. No treatment is required except repair of defective areas, filling all form tie holes and cleaning up of loose or adhering debris. For surfaces below grade which will receive waterproofing treatment the concrete shall be free of surface irregularities which would interfere with proper and effective application of waterproofing material specified for use.

4.17.3 Surface Finish Type F2

The appearance shall be that of a smooth dense, well- compacted concrete showing the slight marks of well fitted shuttering joints. The Contractor shall make good any blemishes.

4.17.4 Surface Finish Type F3

This finish shall give an appearance of smooth, dense, well-compacted concrete with no shutter marks, stain free and with no discolouration, blemishes, arises, airholes etc. Only lined or coated plywood with very tight joints shall be used to achieve this finish. The panel size shall be uniform and as large as practicable. Any minor blemishes that might occur shall be made good by the Contractor.

4.17.5 Unformed Surfaces

Finishes to unformed surfaces of concrete shall be classified as U1, U2, and U3, 'spaded or bonded concrete'. Where the class of finish is not specified the concrete shall be finished to Class U1.

Class U1 finish is the first stage for Class U2 and U3 finishes and for a bonded concrete surface. Class U1 finish shall be a levelled and screeded, uniform plain or ridged finish which (unless it is being converted to Class U2, U3, or bonded concrete) shall not be disturbed in any way after the initial set and during the period of curing, surplus concrete being struck off immediately after compaction.

Where a bonded concrete surface is specified, the laitance shall be removed from the Class U1 finished surface and the aggregate exposed while the concrete is still green.
A spaded finish shall be a surface free from voids and brought to a reasonably uniform appearance by the use of shovels as it is placed in the Works.

Class U2 finish shall be a wood float finish. Floating shall be done after the initial set of the concrete has taken place and the surface has hardened sufficiently. The concrete shall be worked no more than is necessary to produce a uniform surface free from screed marks.

Class U3 finish shall be a hard smooth steel-trowelled finish. Trowelling shall not commence until the moisture film has disappeared and the concrete has hardened sufficiently to prevent excess laitance from being worked into the surface. The surfaces shall be trowelled under firm pressure and left free from trowel marks.

The addition of dry cement, mortar or water shall not be permitted during any of the above operations.

4.17.6 Integral Cement Finish on Concrete Floor

In all cases where integral cement finish on a concrete floor has been specified, the top layer of concrete shall be screeded off to proper level and tamped with tamper so that the aggregate shall be forced below the surface. The surface shall be finished with a wooden float and a trowel with pressure. The finish shall be continued till the concrete reaches its initial set. No cement or cement mortar finish shall be provided on the surface. Where specified, a floor hardener as approved by the Engineer shall be supplied and used as recommended by the manufacturer.

4.18 Repair and Replacement of Unsatisfactory Concrete

Immediately after the shuttering is removed, all the defective areas such as honey-combed surfaces, rough patches, and holes left by form bolts etc. shall be inspected by the Engineer who may permit patching of the defective areas or reject the concrete work.

All through holes for shuttering shall be filled for full depth and neatly plugged flush with surface.

Rejected concrete shall be removed and replaced by the Contractor at no additional cost to the Employer.

For patching of defective areas all loose materials shall be removed and the surface shall be prepared as approved by the Engineer.

Bonding between hardened and fresh concrete shall be done either by placing cement mortar with approved bonding agent or by applying epoxy. The decision of the Engineer as to the method of repairs to be adopted shall be final and binding on the Contractor. The surface shall be saturated with water for 24 hours before patching is done with 1:5 cement sand mortar. The use of epoxy for bonding fresh concrete shall be carried out as approved by the Engineer.
All the form bolt repairs and delayed repairs shall be carried out using a proportion of white cement in repair mix to the approval of the Engineer, so as to match the colour of the surrounding area.

4.19 Vacuum Dewatering of Slabs

Where specified floor slabs, either grade or suspended, shall be finished by vacuum dewatering including all operations such as poker vibration, surface vibration, vacuum processing, floating and trowelling as per equipment manufacturers recommendation. The equipment to be used shall be subject to the Engineer's approval.

4.20 Hot Weather Requirements

Concreting during hot weather shall be carried out as per IS: 7861 (Part I).

Adequate provisions shall be made to lower concrete temperatures which shall not exceed 33^{o} C at the time of placement of fresh concrete.

Where directed by the Engineer, the Contractor shall spray non-wax based curing compound on unformed concrete surfaces at no extra costs.

4.21 Liquid Retaining Structures

The Contractor shall take special care for concrete for liquid retaining structures, underground structures and those others specifically called for to guarantee the finish and water tightness.

The minimum level of surface finish for liquid retaining structures shall be Type F2. All such structures shall be hydro-tested.

The Contractor shall make all arrangements for hydro-testing of structure, all arrangements for testing such as temporary bulk heads, pressure gauges, pumps, pipe lines etc.

Any temporary arrangements that may have to be made to ensure stability of the structures shall also be considered to have been taken into account while quoting the rates.

Any leakage that may occur during the hydro-test or subsequently during the defects liability period or the period for which the structure is guaranteed shall be effectively stopped either by cement/epoxy pressure grouting, guniting or such other methods as may be approved by the Engineer. All such rectification shall be done by the Contractor to the entire satisfaction of the Employer/Engineer at no extra cost to the Employer.

4.22 Testing Concrete Structures for Leakage

Hydro-static test for water tightness shall be done at full storage level or soffit of cover slab, as may be directed by the Engineer, as described below:

In case of structures whose external faces are exposed, such as elevated tanks, the requirements of the test shall be deemed to be satisfied if the external faces show no sign of leakage or sweating and remain completely dry during the period of observation of seven days after allowing a seven day period for absorption after filling with water.

In the case of structures whose external faces are buried and are not accessible for inspection, such as underground tanks, the structures shall be filled with water and after the expiry of seven days after the filling; the level of the surface of the water shall be recorded. The level of water shall be recorded again at subsequent intervals of 24 hrs. over a period of seven days. Backfilling shall be withheld till the tanks are tested. The total drop in surface level over a period for seven days shall be taken as an indication of the water tightness of the structure. The Engineer shall decide on the actual permissible nature of this drop in the surface level, taking into account whether the structures are open or closed and the corresponding effect it has on evaporation losses. Unless specified otherwise, a structure whose top is covered shall be deemed to be water tight if the total drop in the surface level over a period of seven days does not exceed 40 mm.

Each compartment/segment of the structure shall be tested individually.
For structures such as pipes, tunnels etc. the hydrostatic test shall be carried out by filling with water, after curing as specified, and subjecting to the specified test pressure for specified period. If during this period the loss of water does not exceed the equivalent of the specified rate, the structure shall be considered to have successfully passed the test.

4.23 Optional Tests

If the Engineer is not satisfied with the results of the tests under Clause 4.5 or otherwise considers that the materials i.e. cement, sand, coarse aggregates, reinforcement and water are not in accordance with the Specifications or if specified concrete strengths are not obtained, he may order tests to be carried out on these materials in laboratory, to be approved by the Engineer, as per relevant IS Codes. Contractor shall have to pay for these tests.

In the event of any work being suspected of faulty material or workmanship requiring its removal or if the works cubes do not give the stipulated strengths, the Engineer reserves the right to order the Contractor to take out cores and conduct tests on them or do ultrasonic testing or load testing of structure, etc. The Engineer also reserves the right to ask the Contractor to dismantle and re-do such unacceptable work, at no cost to the Employer.

If the structure is certified as failed by Engineer, the cost of the test and subsequent dismantling/reconstruction shall be borne by the Contractor.

The quoted unit rates/prices of concrete shall be deemed to provide for all tests mentioned above.

4.24 Grouting

4.24.1 Standard Grout

Grout shall be provided as specified on the drawings. The proportion of Standard Grout shall be such as to produce a flow able mixture consistent with minimum water content and shrinkage. Surfaces to be grouted shall be thoroughly roughened and cleaned. All Structural steel elements to be grouted shall be cleaned of oil, grease, dirt etc. The use of hot, strong caustic solution for this purpose will be permitted. Prior to grouting, the hardened concrete shall be saturated with water and just before grouting water in all pockets shall be removed. Grouting once started shall be done quickly and continuously. Variation in grout mixes and procedures shall be permitted if approved by Engineer. The grout proportions shall be limited as follows:

Use	Grout thickness	Mix Proportion	W/C ratio (max)
a) Fluid Mix	Under 25mm	One part Portland Cement to one part of sand	0.44
b) General Mix	25mm and above but less than 50mm	One part Portland Cement to two parts of sand	0.53
c) Stiff Mix	50mm and over	One part Portland Cement to three parts of sand	0.53

4.24.2 Non-Shrink Grout

Non – shrink grout where required shall be provided in strict accordance with the manufacturer‘s instructions / specifications on the drawings.

Non-shrinking grout shall be used for grouting of machine base plates, anchor bolts, other anchoring devices and at locations where ordinary grouts are ineffective due to shrinkage. It shall be composed of a type of expansive hydraulic sheeting binder and select-graded aggregates. It shall have properties as per "*Table 11: Proportions for Non-Shrinking Grout*".

Table 11: Proportions for Non-Shrinking Grout

S. No.	Properties	Values
1	Maximum grain size	6 mm
2	Water % (for 80% flow)	15.17
3	Density of hardened grout	2.27 – 2.30 gm/m
4	Compressive strength N/sqmm	
	Minimum 3 days	23
	7 days	34

Mixing, batching, cleaning, preparation of surface and curing of non-shrinking grout shall be done as per manufacturer's instructions.

4.25 Inspection

a. All materials, workmanship and finished construction shall be subject to continuous inspection and approval of the Engineer.
b. All materials supplied by the Contractor and all work or construction performed by the Contractor which is rejected as not being in conformity with the specifications and requirements, shall be immediately replaced.
c. All concrete shall be protected against damage until final acceptance by the Engineer.

4.26 Clean-Up

a. Upon completion of the concrete work, all forms, equipment, construction tools, protective coverings and any debris resulting from the work shall be removed from the premises.

b. All debris i.e. empty containers, scrap wood, etc., shall be removed to "dump" daily, or as directed by the Engineer.

c. The finished concrete surfaces shall be left in a clean condition satisfactory to the Engineer.

.

4.27 Acceptance Criteria

Any concrete work shall satisfy the requirements given below individually and collectively for it to be acceptable.

a) Properties of constituent materials;
b) Characteristic compressive strength;
c) Specified mix proportions;
d) Minimum cement content;
e) Maximum free-water/cement ratio;
f) Workability
g) Temperature of fresh concrete;
h) Density of fully compacted concrete;
i) Cover to embedded steel;
j) Curing;
k) Tolerances in dimensions;
l) Tolerances in levels;
m) Durability;
n) Surface finishes;
o) Special requirements such as;
    i) Water tightness
    ii) Resistance to aggressive chemicals
    iii) Resistance to freezing and thawing
    iv) Very high strength
    v) Improved fire resistance
    vi) Wear resistance
    vii) Resistance to early thermal cracking

The Engineer's decision as to the acceptability or otherwise of any concrete work shall be final and binding on the Contractor.

For work not accepted, the Engineer may review and decide whether remedial measures are feasible so as to render the work acceptable. The Engineer shall in that case direct the Contractor to undertake and execute the remedial measures. These shall be expeditiously and effectively implemented by the Contractor. Nothing extra shall become payable to the Contractor by the Employer for executing the remedial measures.

4.28 Mode of Measurement and Payment

The unit rate for concrete work under various categories shall be all inclusive and no claims for extra payment on account of such items as leaving holes, embedding inserts, etc. shall be entertained unless separately provided for in the Schedule of Quantities. No extra claim shall also be entertained due to change in the number, position and/or dimensions of holes, slots or openings, sleeves, inserts or on

account of any increased lift, lead of scaffolding etc. All these factors should be taken into consideration while quoting the unit rates. Unless provided for in the Schedule of Quantities the rates shall also include fixing inserts in all concrete work, whenever required.

Payments for concrete will be made on the basis of unit rates quoted for the respective items in the Schedule of Quantities. No deduction in the concrete quantity will be made for reinforcements, inserts etc. and opening less than 0.100 of a sq.m. and 0.010 cu.m where concrete is measured in cu.metres. Where no such deduction for concrete is made, payment for shuttering work provided for such holes, pockets, etc. will not be made. Similarly the unit rates for concrete work shall be inclusive or exclusive of shuttering as provided for in the Schedule of Quantities.

Payment for beams will be made for the quantity based on the depth being reckoned from the underside of the slabs and length measured as the clear distance between supports. Payment for columns shall be made for the quantity based on height reckoned upto the underside of slabs/beams.

The unit rate for precast concrete members shall include formwork, mouldings, finishing, hoisting and setting in position including setting mortar, provision of lifting arrangement etc. complete. Reinforcement and inserts shall be measured and paid for separately under respective item rates.

Only the actual quantity of steel embedded in concrete including laps as shown on drawings or as approved by Engineer shall be measured and paid for, irrespective of the level or height at which the work is done. The unit rate for reinforcement shall include all wastages, binding wires, chairs, spacer bars etc. For which no separate payment shall be made.

Where the formwork is paid for separately, it shall be very clearly understood the payment for formwork is inclusive of formwork, shuttering, shoring, propping scaffolding etc. Only the net area of concrete formed (shuttered) shall be measured for payment.

4.29 Water stops

4.29.1 Material

The material for the PVC waterstops shall be a plastic compound with the basic resin of polyvinyl chloride and additional resins, plasticizers, inhibitors, which satisfies the performance characteristics specified below as per IS:12200. Testing shall be in accordance with IS: 8543.

a)	Tensile strength	:	11.6 N/mm^2 minimum
b)	Ultimate elongation	:	300% minimum
c)	Tear resistance	:	4.9 N/mm^2 minimum
d)	Stiffness in flexure	:	2.46 N/mm^2 minimum
e)	Accelerated extraction		
	i) Tensile strength	:	10.50 N/mm^2 minimum
	ii) Ultimate elongation	:	250% minimum
(f)	Effect of Alkali	:	7 days
	i) Weight increase	:	0.10% maximum
	ii Weight decrease	:	0.10% maximum
	iii) Hardness change	:	± 5 points
(g)	Effect of Alkali	:	28 days
	i) Weight increase	:	0.40% maximum
	ii) Weight decrease	:	0.30% maximum
	iii) Dimension change	:	±1%

PVC water stops shall be either of the bar type, serrated with centre bulb and end grips for use within the concrete elements or of the surface (kicker) type for external use.

Flexible water stops shall be fully supported in the formwork, free of nails and clear of reinforcement and other fixtures. Damaged water stops shall be replaced and during concreting care shall be taken to place the concrete so that water stops do not bend or distort.

PVC water stops shall be of approved manufacture. Samples and the test certificate shall be got approved by the Engineer before procurement for incorporation in the works.

4.29.2 Workmanship

Waterstops shall be cleaned before placing them in position Oil or grease shall be removed thoroughly using water and suitable detergents.

Waterstops shall be procured in long lengths as manufactured to avoid joints as far as possible. Standard L or T type of intersection pieces shall be procured for use depending on their requirement. Any non-standard junctions shall be made by cutting the pieces to profile for jointing. Lapping of waterstops shall not be permitted. All jointing shall be of fusion welded type as per manufacturer's instructions.

Waterstops shall be placed at the correct location/level and suitably supported at intervals with the reinforcement to ensure that it does not deviate from its intended position during concreting and vibrating. Particular care shall also be taken to ensure that no honey-combing occurs because of the serrations/end grips. Projecting portions of the waterstops embedded in concrete shall be thoroughly cleaned of all mortar/ concrete coating before resuming further concreting operations. The projecting waterstop shall also be suitably supported at intervals with the reinforcement to maintain its intended position during concreting so as to ensure that it does not bend leading to formation of pockets.

4.29.3 Measurement

Measurement shall be in running metres correct to two places of decimal. No separate payment shall be made for joints or intersection pieces.

4.30 Curing, Protecting, Repairing and Finishing

4.30.1 Curing

All concrete shall be cured by keeping it continuously damp for the period of time required for complete hydration and hardening to take place. Preference shall be given to the use of continuous sprays, or ponded water, continuously saturated coverings of sacking, canvas, hessain or other absorbent materials, or approved effective curing compounds applied with spraying equipment capable of producing a smooth, even textured coat. Extra precautions shall be exercised in curing concrete during cold and hot weather as outlined hereinafter. The quality of curing water shall be the same as that used for mixing concrete.

4.30.2 Curing with Water

Fresh concrete shall be kept continuously wet for a minimum period of 10 days from the date of placing of concrete, following a lapse of 12 to 14 hours after laying of concrete. The curing of horizontal surfaces exposed to the drying winds shall however begin as soon as the concrete has hardened. Water shall be applied to formed surfaces immediately upon removal of forms. Quantity of water applied shall be controlled so as to prevent erosion of freshly placed concrete.

4.30.3 Continuous Spraying

Curing shall be assured by use of an ample water supply under pressure in pipes, with all necessary appliances of hose, sprinklers and spraying devices. Continuous fine mist spraying or sprinkling shall be used, unless otherwise specified or approved by the Engineer.

4.30.4 Alternate Curing Methods

Whenever in the judgment of the Engineer, it is necessary to omit the continuous spray method, a covering of clean sand or other approved means such as wet gunny bags, which will prevent loss of moisture from the concrete, may be used. No type of covering will be approved which would stain or damage the concrete during or after the curing period. Covering shall be kept continuously wet during curing period. For curing of concrete in sidewalks, floors, flat roofs of other level surfaces, the ponding method of curing is preferred. The method of containing the ponded water shall be approved by the Engineer. Special attention shall be given to edges and corners of the slabs to ensure proper protection to these areas. The ponded areas shall be kept continuously filled with water during the curing period.

4.30.5 Curing Compound

Surface coating type-curing compounds shall be used only by special permission of Engineer. Curing compounds shall be liquid type white pigmented, confirming to US Bureau of Reclamation specification. No curing compound shall be used on surfaces where future blending with concrete, water of acid proof membrane or painting is specified.

4.30.6 Curing Equipment

All equipment and materials required for curing shall be on hand and ready for use before concrete is placed.

4.31 `Protecting Fresh Concrete

Fresh concrete shall be protected from defacements and damage due to construction operations by leaving forms in place for an ample period. Newly placed concrete shall be protected by approved means such as tarpaulins from rain, sun and winds. Steps as approved by the Engineers hall also be taken to protect immature concrete from damage by debris, excessive lading, vibration, abrasion or contact with other materials, etc. that may impair the strength and/or durability of the concrete. Workmen shall be warned against and prevented from disturbing green concrete during its setting period. If it is necessary that the workmen enter the area of freshly placed concrete, the Engineer may require that bridges be placed over the area.

4.32 Repair and Replacement of Unsatisfactory Concrete

4.32.1 General

Immediately after the shuttering is removed, the surface of concrete shall be very carefully inspected and all defective areas attended to by the Engineer may permit patching of the defective areas or reject the concrete unit either partially or entirely. Rejected concrete shall be removed and replaced by the contractor. Holes shall be filled with mortar composed of one part of cement to one and half parts of sand passing 2.36 mm IS sieve after removing any loose stones adhering to the concrete. Concrete surfaces shall be finished as described in specifications or as directed by the Engineer. Superficial honey combed surfaces and rough patches shall be similarly made good immediately after removal of shuttering, in the presence of the Engineer and superficial water and air holes shall be filled in. The mortar shall be well worked into the surface with a wooden float. Excess water shall be avoided. Unless instructed otherwise by the Engineer, the surface of the exposed concrete placed against shuttering shall be rubbed down immediately on removal of shuttering to remove fine or other irregularities, care being taken to avoid damaging the surface. Surface irregularities shall be removed by grinding. If reinforcement is exposed or the honeycombing occurs at vulnerable positions e.g. ends of beams or columns, it may be necessary to cut out the member completely or in part and reconstruct. The decision of the Engineer shall be final in this regard. If only patching is necessary, the edges being cut perpendicular to the affected surface or with a small undercut if possible. Anchors, tees or dovetail slots shall be provided whenever necessary to attach the new concrete securely in place. An area

extending several centimeters beyond the edges and the surfaces of the prepared voids shall be saturated with water for 24 hours immediately before the patching material is placed.

4.32.2 Use of Epoxy

The use of epoxy for bonding fresh concrete used for repairs will be permitted upon written approval of the Engineer. Epoxies shall be applied in strict accordance with the instructions of the manufacturer.

4.32.3 Method of Repair

Small size holes having surface dimensions about equal to the depth of the hole, holes left after removal of form bolts, grout insert holes and slots cut for repair of cracks shall be repaired as follows.

The hole to be patched shall be roughened and thoroughly soaked with clean water until absorption stops. A 5 mm thick layer of grout of equal parts of cement and sand shall be well brushed into the surface to be patched, followed immediately by the patching concrete which shall be well consolidated with a wooden float and left slightly protrude of the surrounding surface. The concrete patch shall be built up in 10 mm thick layers, after an hour or more, depending upon weather conditions, it shall be worked off flush with a wooden float and a smooth finish obtained by wiping with hessian. A steel trowel shall be used for this purpose. The mix for patching shall be of the same materials and in the same proportion as that used in the concrete being repaired, although some reduction in the maximum size of the coarse aggregates may be necessary and the mix shall be kept as dry as possible. Mortar filling by air pressure (gunniting) shall be used for repair of areas too large and/or too shallow for patching with mortar. Patched surfaces shall be given a final treatment to match the colour and texture of the surrounding concrete. White cement shall be substituted for ordinary cement, if so directed by the Engineer, to match the shade of the patch with the original concrete.

4.32.4 Curing of Patched Work

The patched area shall be covered immediately with an approved non-staining, water-saturated material such as gunny bags which shall be kept continuously wet and protected against sun and wind for a period of 24 hours. Thereafter, the patched area shall be kept wet continuously by a fine spray, or sprinkling for not less than 10 days. All fillings shall be tightly bounded to the concrete and shall be sound, free from shrinkage cracks after the fillings have been cured and dried.

4.33 Approval by the Engineer

All materials, procedures and operations used in the repair work shall be subject to the approval of the Engineer.

4.33.1 Precast Concrete

4.33.1.1 General

Precast concrete units, whether manufactured on or off site, shall comply in every way with the provisions of the contract for in situ concrete. Wherever possible, precast units shall be hydraulically pressed. When ready for incorporation in the works, precast units shall be responsible for the accuracy of the level, shape of the bed or platform. A suitable serial number and the date of casting shall be impressed or painted on each unit.

4.33.1.2 Striking Forms

Side shutters shall not be struck in less than 24 hours after depositing concrete and no precast unit shall be lifted until the concrete reaches strength of at least twice the stress to which the concrete may be subjected to at the time of lifting.

4.33.1.3 Precast Units

The lifting and removal of precast units shall be undertaken without causing shock, vibration or undue bending stresses to or in the units. Before lifting and removal takes place, contractor shall satisfy the Engineer or his representative that the methods he proposes to adopt for these operations will not over-stress or otherwise effect seriously the strength of the precast units. The reinforced side of the units shall be distinctly marked.

4.33.1.4 Curing

All precast work shall be protected from the direct rays of the sun for at least 7 days after casting and during that period each unit shall be kept constantly watered or preferably be completely immersed in water if the size of the unit so permits.

4.34 Slots, Openings, etc.

4.34.1 General

Slots, openings or holes, pockets, etc., shall be provided in the concrete work in the approved positions or as directed by Engineer. Short pipes with puddle collar shall be fixed in the sidewall of suction pipes. They shall be supplied at the appropriate time during construction. Any deviation from the approved drawings shall be made good by contractor at own expense, without damaging any other work. Sleeves, bolts, inserts etc., shall also be provided in concrete work where so required.

4.35 Preformed Fillers and Joint Sealing Compound

4.35.1 Materials

Preformed filler for expansion/isolation joints shall be non-extruding and resilient type of bitumen impregnated fibres conforming to IS: 1838 (Part I).
Bitumen coat to concrete/masonry surfaces for fixing the preformed bitumen filler strip shall conform to IS: 702. Bitumen primer shall conform to IS: 3384.

Sealants shall be of the following types:

4.35.1.1 Sealant Type A

Sealant Type A shall be a gun grade, non-slumping compound suitable for sealing horizontal, vertical and soffit joints in water retaining structures. It shall be a UK WFBS material approved for unrestricted use in contact with potable water to the full exposure condition of 15000 mm^2/l, and shall not support bacterial growth.
It shall be stable and shall have a low water absorption and good adhesion to concrete.

Hardness (Shore A)	:	> 12
Transverse Movement Accommodation	:	±15%

4.35.1.2 Sealant Type B

Sealant type shall be a gun grade compound, suitable for sealing vertical movement and construction joints in concrete structures. It shall be flexible, resistant to aging, physical damage and weathering and shall have good adhesion to concrete.

Hardness (Shore A)	:	> 12
Transverse Movement Accommodation	:	±12.5%

4.35.1.3 Sealant Type C

Sealant type C shall be similar to Type B above. In addition it shall have been designed for sealing movement and construction joints in hydraulic and water retaining structures and shall be suitable for use in contact with potable water.

Hardness (Shore A)	:	> 20

Transverse Movement Accommodation : ±12.5%

4.35.1.4 Sealant Type D

Sealant Type D shall be a pourable compound suitable for sealing horizontal movement and construction joints in concrete structures. It shall be flexible, resistant to aging, physical damage and weathering and shall have good adhesion to concrete.

Hardness (Shore A) : > 9
Transverse Movement Accommodation : ±12.5%

4.35.1.5 Sealant Type E

Sealant Type E shall be a cold pouring compound complying with BS 5212, suitable for sealing movement and construction joints in concrete paved areas. It shall be resistant to fuels, oils and hydraulic fluids. It shall be tough, abrasion-resistant and shall not decompose in strong sunlight.

Hardness (Shore A) : > 12
Transverse Movement Accommodation : ±12.5%

4.35.1.6 Approved Sealants

The following approved sealants meet the above specifications.

Sealant Type A, B and C : Thioflex 600 gun grade
Sealant Type : Thioflex 600 pourable grade
Sealant Type E : Colpor 200

The hardness value specified in the above summaries is the Shore A Durometer value at 14 days at 25^{o} C and 50% RH. The specified transverse movement values are based on joints having a width to depth ratio of 1.5: 1.

The Contractor may use the above sealants or ones meeting equivalent or higher specifications.

4.35.1.7 Workmanship

The thickness of the preformed bitumen filler shall be 25mm for expansion joints and 50mm for isolation joints around foundation supporting rotatory equipments. Contractor shall procure the strips of the desired thickness and width in lengths as manufactured. Assembly of small pieces/thicknesses of strips to make up the specified size shall not be permitted.

The concrete/masonry surface shall be cleaned free from dust and any loose particles. When the surface is dry, one coat of industrial blown type bitumen of grade 85/25 conforming to IS:702 shall be applied hot by brushing at the rate of 1.20 kg/sq.m. When the bitumen is still hot the preformed bitumen filler shall be pressed and held in position till it completely adheres. The surface of the filler against which further concreting/masonry work is to be done shall similarly be applied with one coat of hot bitumen at the rate of 1.20 kg/sq.m.

Sealing compound shall be heated to a pouring consistency for enabling it to run molten in a uniform manner into the joint. Before pouring the sealing compound, the vertical faces of the concrete joint shall be applied hot with a coat of bitumen primer conforming to IS:3384 in order to improve the adhesive quality of the sealing compound.

Expansion joints between beams/slabs shall be provided with 100mm wide x 4mm thick mild steel plate at the soffit of RCC beams/slabs to support and prevent the preformed joint filler from dislodging. This plate shall be welded to an edge angle of ISA 50 x 50 x 6mm provided at the bottom corner, adjacent to the expansion joint of one of the beams/slabs, by intermittent fillet welding. Steel surfaces shall be provided with 2 coats of red oxide zinc chrome primer and 3 coats of synthetic enamel paint finish.

The Contractor shall construct recesses at all joints and on both faces of the concrete work except on the underside of ground slabs. The recesses shall be accurately formed to the lines and dimensions shown on the Drawings or as agreed with the Engineer.

The Contractor shall prepare the surfaces of the recess and shall supply a joint sealer and fill or caulk the recess completely with it.

Joint sealing shall not be commenced without the approval of the Engineer. In reservoir joints the sealer shall be poured after completion of the water tightness test, to the satisfaction of the Engineer.

All joint sealers shall be from an approved manufacturer. The Contractor shall supply the manufacturer's test certificates for each consignment of each type of joint sealant delivered to the Site and shall if requested supply to the Engineer sufficient samples of each type and consignment for confirmatory tests to be carried out in accordance with the appropriate test procedure.

Sealants shall be installed in strict accordance with the manufacturer's instructions. De-bonding strip shall be used in conjunction with the sealers as indicated on the Drawings. The de-bonding strip shall be compatible with the joint sealer and shall be resistant to attach from the primer used to bond the sealer to the concrete.

Polysulphide and polyurethane sealants shall not abut bitumen sealers. Surfaces to receive Polysulphide and polyurethane sealants shall be kept free from bituminous paints. All sealants shall be appropriate for the prevailing climatic conditions. Bituminous sealants shall comply with the BS 2499 for Type A1. Polysulphide sealants shall comply with IS 12118.

4.35.1.8 Measurement

Measurement for the preformed joint filler shall be in sq.m correct to two places of decimal for the specified thickness as per items of work. Measurement for applying the bitumen coat to concrete/masonry surfaces shall be in sq.m correct to two places of decimal. Measurement for the joint sealing compound shall be in running metres correct to two places of decimal for the specified width and thickness as per the items of work. Measurement for the mild steel corner angle and plate shall be by weight as per the items of work.

4.36 Concreting Records

A written record of the concrete works shall be made each day by the Contractor and kept available for inspection by the Engineer. The diary shall contain notes and records of:

(a) The names of the Contractor's Engineer who are responsible for the different phases of the concrete work and also the names of their assistants.

(b) The temperatures of air, water, cement, aggregate, together with the air humidity and type of weather.

(c) Deliveries to the Site of concrete materials (quantity, brand of concrete, etc).

(d) Inspections carried out, tests performed, etc. and their results.

(e) Times of commencement and completion of different parts of the concrete works and times of erection and striking of forms.

(f) Quantity of cement, fine and coarse aggregate and admixture used for each section of work and the number and kind of test samples taken on these ingredients and water.

CONCRETE POUR CARD

CLIENT : DATE : POUR NO. :

PROJECT : STRUCTURE :

Contractor : MAX. AGGREGATE SIZE/ SLUMP :

START / COMPLETION TIME : /

DRG. NO. :

MIXING TIME :

CONCRETE GRADE / QUANTITY : /

SL. NO.	ITEM			Contractor's Rep. Sign	Engineer's Sign	Remarks
1.	BEFORECONCRETING	CENTRELINES CHECKED				POUR AUTHORISED SITE ENGINEER
2.		FORMWORK AND STAGING CHECKED FOR ACCURACY, STRENGTH & FINISH				
3.		REINFORCEMENT CHECKED				
4.		COVER TO REINFORCEMENT CHECKED				
5.		VERIFIED TEST CERTIFICATE FOR CEMENT/STEEL		YES / NO	YES / NO	
6.		ADEQUACY OF MATERIALS / EQUIPMENT FOR POUR		YES / NO	YES / NO	
7.		EMBEDDED PARTS	CIVIL			
		CHECKED	MECHANICAL			

		(LOCATION & PLUMB)	ELECTRICAL			
8.	SOFFIT(S) & POUR TOP(T) LEVELS CHECKED BEFORE (B) & AFTER (A) FORM REMOVAL (ONLY OF BEAMS OF OVER 10 M SPAN & IMPORTANT STRUCTURE LIKE T.G. ETC.)			S(B) T(B) S(A) T(A)		
9.	CONSTRUCTION JOINTS LOCATION & TIME (IF NOT AS PER DRAWING)					
10.	CEMENT CONSUMPTION IN KGS.					
11.	NUMBER OF CUBES AND IDENTIFICATION MARKS					
12.	TEST CUBE RESULTS (7 DAYS / 28 DAYS)					
13.	CONCRETE CONDITION ON FORM REMOVAL			V.GOOD/GOOD/FAIR/POOR		

SITE-IN-CHARGE

NOTES : 1. EACH ITEM TO BE CHECKED AND SIGNED BY THE RESPECTIVE ENGINEERS.

2. ITEMS 8 TO 13 (BOTH INCLUSIVE) TO BE FILLED ONLY BY ENGINEER.

3. EACH POUR TO HAVE SEPARATE CARDS, IN TRIPLICATE ONE EACH FOR CLIENT, CONSULTANT & SITE OFFICE.

UNDER REMARKS INDICATE DEVIATIONS FROM DWGS. & SPECIFICATIONS, CONGESTION IN REINFORCEMENT IF ANY, UNUSUAL OCCURENCES, SUCH AS FAILURE OF EQUIPMENTS, SINKING OF SUPPORTS / PROPS. HEAVY RAINS AFFECTING CONCRETING, POOR COMPACTION, IMPROPER CURING, OTHER DEFICIENCIES, OBSERVATIONS ETC.

End of Section-4